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Does small-sided-games' court area influence metabolic, perceptual, and physical performance parameters of young elite basketball players?

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ABSTRACT: The purpose of this study was to investigate the effect of court size on physiological responses and physical performance of young elite basketball players. Twelve male basketball players (18.6 ± 0.5 years; 88.8 ± 14.5 kg; 192.6 ± 6.5 cm) from an under-19 team performed two small-sided games (matches) with different court areas (28x15 m and 28x9 m; 28x15 and 28x9 protocols). The number of players (3x3) was kept the same in each protocol. The players performed a repeated-sprint ability (RSA) test before and after each match. Blood lactate concentration was collected before (pre) and after (post) the matches, and the session rating of perceived exertion (session-RPE) was determined 30 minutes after the match. Best and mean time in the RSA test were not different between the 28x15 and the 28x9 match protocols ($p>0.05$). A significant difference was observed for lactate concentration from pre- to post-match ($p<0.05$) in both protocols (28x15 and 28x9); however, there was no significant interaction between protocols. A similar session-RPE mean score (28x15: 7.2 ± 1.4 and 28x9: 6.6 ± 1.4) was detected for both protocols ($p>0.05$, ES=0.41). In summary, the results of the current study suggest that the different court areas induced similar responses. Although there was no significant difference in effort perception, players tended to perceive a greater effort in the larger court size.

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INTRODUCTION

Basketball is an intermittent team sport characterized by a high frequency of high-intensity actions and changes of direction over short distances, eliciting considerable physiologic and metabolic demands [1-2]. Accordingly, in order to cope with such elevated match-associated demands, basketball players are required to develop a high level of physical conditioning.

From a practical standpoint, basketball coaches have been searching for training methods which might mimic the real match demands, aiming to develop sport-specific skills while concomitantly improving physical fitness performance. Among them, the most popular method is so-called "small-sided games" (SSG), which have recently received considerable attention by coaches and researchers [3-5]. SSG are modified games that are played in different court areas with adapted rules and involve different numbers of players [5].

The characterization of acute and physiological responses to different SSG can help coaches and supporting staff to prescribe appropriate training loads and ensure optimal scheduling of training content. Factors such as court dimensions, number of players and playing rules have been shown to influence the acute responses to SSG in different team sports [3, 6-7].

However, few studies have been conducted on basketball players. Among those which have been carried out, Castagna et al. [3] demonstrated that reducing the number of players while keeping the court area fixed could induce a higher cardiovascular response in the 3x3 format (%HRmax: 88.0 ± 8.4%) compared to the 5x5 format (%HRmax: 84 ± 9.2%), as well as a higher lactate concentration in the 3x3 format (6.2 ± 2.3) when compared to the 5x5 format (4.2 ± 1.8 mmol·L^{-1}). Moreover, Klusemann et al. [8] investigated the effect of number of players (2x2 and 4x4), work-to-rest ratio (4x2.5 min with 60 s recovery, and 2x5 min with 30 s rest at half time), and court area (half versus full court) on physiological, perceptual, physical, and technical parameters. These authors also showed that a reduced number of players in the same court area induced higher cardiovascular (%HRmax) and perceptual (RPE) responses. Mean heart rate and RPE were higher in the 2x5 min protocol. Moreover, the number of players, court size, and work-to-rest ratio influenced the movement patterns. For example, a higher frequency of sprints, high intensity shuffling movements and jumps were observed with the 2x2 protocol, suggesting that the relative court area per player could affect physical performance parameters.

Nevertheless, less is known about the effect of court area on acute responses of different physical performance parameters. While several physical performance parameters, such as sprint time, jump height, or muscle strength, can be used to measure specific physical attributes, repeated-sprint ability (RSA) is a complex quality that has been related to both neuromuscular (e.g., peak locomotor speed, neural drive, and motor unit activation) and metabolic factors (e.g., oxidative capacity, PCr recovery and H+ buffering) [9-11]. As such, RSA tests can be used as an index of whole-body physical performance [10] to quantify SSG-induced fatigue.

Therefore, the purpose of this study was to determine the effect of court area on physiological responses and physical performance of elite young basketball players. It was hypothesized that the greater court area would impose higher demands on players. Additionally, it was expected that the greater area with elevated demands could induce a higher level of acute fatigue, leading therefore to a greater decrement in RSA performance.

MATERIALS AND METHODS

Subjects. Twelve male basketball players volunteered for this study (mean ± SD =18.6 ± 0.5 years; 88.8 ± 14.5 kg; 192.6 ± 6.5 cm). They belonged to an under-19 team playing in the main São Paulo (Brazil) basketball competition. The study was developed during the 2011 regular competitive season. The investigated team achieved third place at the 2011 São Paulo State Championship. The only two inclusion criteria to take part in the present investigation, besides being part of the assessed basketball team, were the following: 1) the players were required to participate fully in the two SSG protocols with different court areas (28x15 vs. 28x9), 2) they had to complete all RSA tests and provide session-RPE and blood samples at all required time-points. Prior to commencement of the study all players underwent a thorough medical screening to assess health status. All players were free from illness at the start of the experiment and none were taking any prescribed medication during the course of the study. All the players were familiarized with the SSG procedures which were used during their habitual training programme. After being informed of the experimental procedures, including benefits and potential risks, participants gave written consent for participation in the study. The research procedures were approved by the local University Research Ethics Committee.

Study Design

This investigation was designed to examine the effect of two different SSG protocols on physiological responses and physical performance of young basketball players. The protocols were different regarding the court area: the official basketball court area was adopted (length 28 m and width 15 m; 28x15) in one protocol while a reduced width area was adopted in the other protocol (length 28 m and width 9 m; 28x9). A pre-post crossover study design was used to conduct the experiment. Subjects were divided into two subgroups (groups A and B), with six players in each. The experimental sessions were performed on two different days separated by 24 h. On day 1, group A performed the 28x15 and group B the 28x9 protocol; on day 2 group A performed the 28x9 and group B the 28x15 protocol. The number of players (3x3) was kept the same for both protocols. The coach was instructed to divide the teams equalizing the technical level of each group of players. The players performed a repeated-sprint ability (RSA) test before and after each protocol (28x15 vs 28x9). Blood lactate was collected before and after each protocol and the session rating of perceived exertion (session-RPE) was determined 30 minutes after the end of each protocol.

Small-Sided Games

Both SSG protocols were performed with a three-a-side team composition (3x3). The SSG were organized in four sets of four minutes, performed under official basketball rules, except for free throw shot, which was not allowed; any foul that would result in the free throw shot was treated as a normal sideline reposition. Additional balls were kept near the sidelines to ensure a quick restart of the SSG at any situation. An active recovery (jogging at free pace) of three minutes between sets was allowed. Players were encouraged to drink water, ad libitum, between game periods (sets).

Repeated Sprint Ability Test (RSA test)

The RSA was performed before and after the SSG (after blood sampling for lactate concentration). The protocol adopted in this study was 12 x 20 m sprints with 20 s of active rest between sprints, as used by Meckel et al. [12]. A photoelectric cell timing system (Multisprint, Hidrofit, MG, Brazil) was used to record the duration of each sprint (accuracy of 0.001 s). Two sets of timing gates were used, one for the start (opening gate) and one for the end (closing gate). Subjects were instructed to decelerate only after the closing gate, and return to the start point to prepare for the next sprint. The return pace was chosen by each subject; however, the instructor gave verbal feedback about the remaining recovery time. A standing start with the front foot placed 50 cm behind the opening gate was used for all sprints. All athletes received verbal encouragement during the test from instructors and coaches.

The best sprint time (BT), mean sprint time (MT), and performance decrement (PD) were registered. PD was calculated by the following equation: PD = (100 x(total sprint time ÷ ideal sprint time))– 100; where total sprint time = sum of 12 sprints; and ideal sprint time = BST x 12 [13].

Blood Lactate Concentration

Blood lactate was collected before (pre) and immediately after SSG (post). Capillary blood samples (25 μL) were drawn from the ear lobe and immediately transferred to a microtube (containing 50 μL of sodium fluoride) and stored at −80°C. The blood samples were analysed electrochemically using the YSI 1500 Sport Analyser (YSI 1500 Sport, OH, EUA) previously calibrated in accordance with the manufacturer's instructions.

Session Rating of Perceived Exertion (session-RPE)

The intensity was determined by the session-RPE method, as proposed by Foster [14], and adopted in previous studies with basketball players [15-18]. Session-RPE was determined by asking each player "*How was your session?*" according to Borg's CR-10 scale, 30 min after the end of the SSG protocols. Players were largely familiar with this method, which was regularly used during their training programme.

Statistical Analyses

All data were presented as mean and standard deviation. Prior to parametric statistical procedures, normality and homoscedasticity were verified using the Kolmogorov–Smirnov and Levene tests, respectively. To compare means, a two-way ANOVA with repeated measures (SSG [28x15 and 28x9] vs. time-points [blood lactate levels and RSA performance – before and after SSG]) was adopted with Bonferroni post-hoc test to locate differences. Statistical significance was set at $p \leq 0.05$. The effect size of the differences was calculated (Cohen's d [19]) and qualitative interpretations were provided as follows: 0–0.19 trivial; 0.2–0.59 small; 0.6–1.19 moderate; 1.2–1.99 large; >2 very large [20]. Statistics were conducted using the SPSS statistical software package (SPSS Inc. 20.0, Chicago, USA) and Microsoft Excel (Microsoft).

RESULTS

The RSA parameters are presented in Table 1. No significant difference between conditions (28x15 vs. 28x9, $p > 0.05$) was observed for BT, MT or PD. Small effect sizes for the magnitude of the difference between pre- and post-28x15 were observed for BT (0.33) and MT (0.40). A trivial effect size was identified for PD (0.12). The lactate response for the two protocols (28x15 vs. 28x9) is shown in Figure 1. The lactate concentration at pre was significantly different to post ($p < 0.00$) for both conditions; there was no significant interaction between conditions (28x15 vs. 28x9). The session-RPE score is shown in Figure 2. No significant difference between protocols was observed (28x15 vs. 28x9; $p > 0.05$). However, a small effect size for the magnitude of the difference between protocols was detected (ES = 0.41).

TABLE 1. Repeated-sprint ability (RSA) test performance before (pre) and after (post) SSG (mean ± SD).

RSA test measures		SSG 28x15	SSG 28x9
Best time (s)	Pre	3.20 ± 0.10	3.18 ± 0.07
	Post	3.24 ±0.14	3.18 ± 0.15
	ES	0.33 (small)	0.03 (trivial)
Mean time (s)	Pre	3.36 ± 0.10	3.37 ± 0.07
	Post	3.43 ± 0.20	3.39 ± 0.25
	ES	0.40 (small)	0.04 (trivial)
Performance decrement (%)	Pre	5.31 ± 3.90	6.15 ± 3.31
	Post	6.01 ± 3.98	6.47 ± 3.03
	ES	0.12 (trivial)	0.06 (trivial)

Note: RSA – repeated-sprint ability; SSG – small-sided game; ES – effect size.

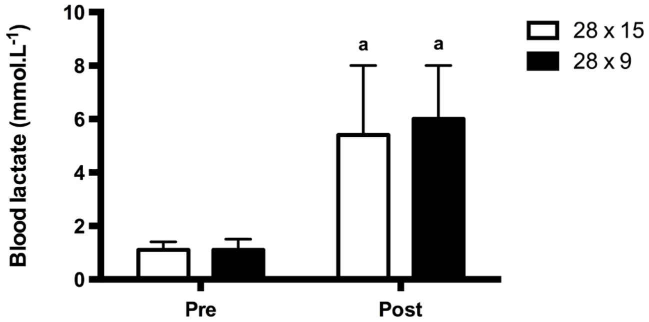

FIG. 1. Lactate concentration response.
a – significant difference to pre ($p < 0.00$); Pre – before SSG; Post – immediately after SSG; SSG28x15 – small-sided game, 28x15 m court area; SSG28x9 – small-sided game, 28x9 m court area.

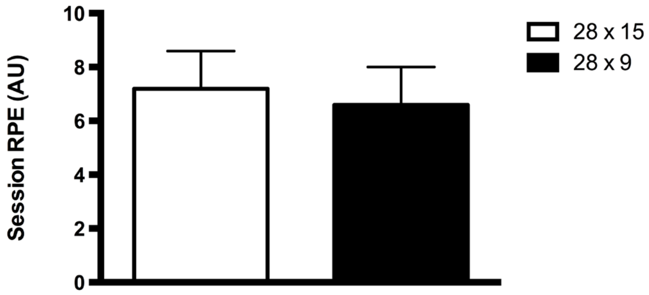

FIG. 2. Session-RPE response.
Notes: small-sided game – 28x15 m court area; small-sided game – 28x9 m court area.

DISCUSSION

This study investigated the effect of different SSG court areas on physiological responses and physical performance of young basketball players. The main finding was that distinct court areas elicited similar responses. There was a significant pre to post increment in lactate concentration but no difference was observed between court size protocols. Although there was no significant difference between protocols in session-RPE score, the athletes seem to perceive a greater effort in a greater relative area. Additionally, a small effect size was observed for the magnitude of the difference between pre and post-28x15 in RSA mean time and best time.

The lactate responses observed in the present study suggest an important activation of the anaerobic metabolism during SSG, which is in line with metabolic responses reported during official basketball matches [1-2]. The results from post-SSG blood lactate concentration observed here are also very similar to those previously reported in basketball players during SSG [3]. Castagna et al. [3] reported values of 4.2 ± 1.8 $mmol \cdot L^{-1}$ for the SSG played with a court area of 42 m^2 per player, and 6.2 ± 2.3 $mmol \cdot L^{-1}$ for the SSG with 70 m^2 per player. The same relative areas per player were adopted in the present investigation, and the blood lactate concentration was 5.6 ± 2.6 $mmol \cdot L^{-1}$ for the 28x15 protocol (70 m^2 per player) and 6.0 ± 2.0 $mmol \cdot L^{-1}$ for the 28x9 protocol (42 m^2 per player). As mentioned previously, it is noteworthy that these values are very close to the values reported for male basketball players during official matches (5.0–6.8 $mmol \cdot L^{-1}$) [1-2, 21]. This similar metabolic response suggests that the SSG protocols were effective in mimicking the actual metabolic demands inherent in basketball matches.

Taking into account the results from Castagna et al. [3] and those presented here, it is reasonable to suggest that SSG of 70 m^2 or 42 m^2 per player, with the proposed rules and structure, may be used as an alternative conditioning training strategy to induce similar metabolic responses to those verified during official matches. This information is considered to be of great practical relevance, as specific training sessions which mimic physiological demands of official matches have been suggested to prepare basketball players for competitive stress [22-23]. Indeed, these findings could aid conditioning coaches in their training planning based on scientific evidence.

The session-RPE scores verified in the present study are very close to those reported by Castagna et al. [3], who reported scores of 4.5 ± 1.8 and 5.8 ± 1.1 for SSG of 42 m^2 and 70 m^2 per player, respectively. Moreover, recently, Klusemann et al. [8] investigated the effect of manipulating court area (SSG; 2-a-side and 4-a-side) and reported RPE scores of 6 ± 2 and 7 ± 2 for half and full-court, respectively, with a moderate magnitude of effect size (0.62) between protocols. Interestingly, in the present investigation, a small effect size (0.41) was observed for the magnitude of the differences between SSG in the session-RPE scores, with a higher value for the 28x15 protocol (7.2 ± 1.4) when compared to the 28x9 protocol (6.6 ± 1.4). These data corroborate reports from Klusemann et al. [8]; in addition, it is noteworthy that this small effect size, with a higher score for the 28x15 condition, may be considered as being relevant for practical purposes.

Collectively, the results of the present study regarding session-RPE and the findings of Klusemann et al. [8] suggest that when playing in a greater court area, basketball players may perceive the effort as more demanding. The magnitude of effect size for the differences between protocols suggests that court area may be an important factor affecting the perceived effort of players and therefore could be taken into account by conditioning coaches when planning training sessions using SSG as the main training strategy.

Another important finding from the present study regarding session-RPE is that the SSG protocols were effective to induce a similar level of effort as compared to official basketball matches [15-16, 24]. For example, Moreira et al. [15] also investigated a sample of elite under-19 basketball players during three official and two simulated matches during the competitive season. The authors reported a mean session-RPE score of 6.0 for official matches, using the CR-10 scale, and also revealed a higher RPE score in official matches compared to simulated matches [15]; yet, speculatively, it seems that the SSG might be a more effective form of mimicking the real internal load of the official matches than simulated matches. However, this hypothesis needs to be assessed in future studies, which could, for instance, compare the physiological responses of basketball players from official basketball matches with those from both simulated matches and SSG.

In another study, Moreira et al. [16] reported a higher internal load in official matches compared to simulated matches in professional basketball players using the session-RPE method. In addition, a significant correlation between session-RPE and cortisol responses during competition was also reported (r = 0.75), which may suggest the validity of the session-RPE method for monitoring internal load in team sports, particularly in basketball players. Moreover, Manzi et al. [24] monitored the magnitude of internal training load by means of session-RPE and 2 heart rate-based (HR) methods and reported the validity of the session-RPE method. These researchers observed significant relationships between individual session-RPE and all individual HR-based training loads (r = 0.69–0.85) for training and competition in elite basketball players. The results from the aforementioned studies in conjunction with those reported here suggest that session-RPE may be a useful tool to assess the internal training load of basketball players during official matches, simulated matches as well as from SSG.

The RSA of basketball players was not impaired despite the elevated perceptual and physiological demand from both SSG protocols (28x15 and 28x9). This result is in agreement with those reported by Meckel et al. [12], who also did not find any significant difference in RSA performance after a simulated basketball match. Nevertheless, Caprino et al. [25] and Delextrat et al. [26] presented different findings. They observed a significant reduction in RSA performance after official basketball matches. The discrepancies between the results of the present study and those reported by Delextrat et al. [26] and Caprino et al. [25] may be attributed to differences in RSA test protocols. The sprint duration (6 s) used by Delextrat et al. [26] and the shuttle sprint distance (15+15m) used by Caprino et al. [25] might have induced higher physical and physiological demands than those in the present study [9, 27-28]. Thus, the performance of RSA tests associated with a longer sprint duration might be more affected by basketball-related fatigue than shorter sprints.

Despite the absence of a significant difference in the RSA test performed before and after the SSG assessed in the present study, a small effect size was observed for the magnitude of the difference between pre- and post-28x15 in the RSA mean time (0.40) and best time (0.33). These results should be highlighted, in particular when translated to the practical setting. From a practical point of view, the effect observed in RSA mean and best times when compared with the pre- and post-28x15 time-points suggests that this format may impose a higher level of fatigue and therefore lead to impaired physical performance. It may be reasonable to assume that this result might demonstrate that for practical purposes a greater court area may not only lead to a greater perceived effort, but also such elevated perceived intensity could be associated with a higher level of fatigue, which in turn impaired high-intensity performance capacity during the RSA test.

Based on the results from the present study, it appears that the SSG court sizes used may be adopted by coaches and conditioning trainers aiming to induce similar metabolic and perceptual demands to those encountered in official basketball matches. SSG court areas (28x15 and 28x9) could be used in specific basketball training as part of the conditioning programme of the basketball players. Additionally, coaches should be aware that the larger court area may elevate perceived effort and may impair high-intensity performance capacity.

CONCLUSIONS

This study showed that the different court areas used in the present study induced similar responses. Although no significant difference was detected between conditions, it seems that players tended to perceive a greater effort when playing on a larger court. In addition, a greater ES regarding the decrement in RSA was observed in the larger court. Future studies could focus on different SSG protocols, notably using greater differences in court area than that used herein, to better understand the acute effect on physiological responses and physical performance.

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